Distribution characteristics and succession regulation of the forests in alpine and canyon region of western Sichuan Province, P. R. China

XIANG Cheng-hua, YANG Yu-po
(*Sichuan Research Institute of Forestry, Chengdu 610081, P. R. China*)

Abstract: Since 1950, 700 plots were established in the alpine and canyon region of western Sichuan. The distribution characteristics and the relationships between forest succession and environmental gradients were studied. The results showed that the main tree species were *Picea* and *Abies* in this region, and there were more than 90 forest types. *Abies* forests mainly distributed in the middle and upper reaches of rivers and their branches, and *Picea* forests mainly distributed in wide valleys and on half-shaded and half-sunny slopes. The natural regeneration was poor under primitive spruce and fir forest canopy, but was good in the spruce and fire forest gap. The relationship between forest succession and vertical gradient was closely related to the relationship between forest succession procession and plant synusia under primary forests. Human activities could promote and postpone succession process. The results of expanding regeneration were often influenced by topography, vegetation and wind direction.

Keywords: Alpine and canyon region; Forest succession; Environmental gradients; Forest gap; Regeneration
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Introduction

The alpine and canyon region in western Sichuan is situated at the southeastern edge of the Qinghai—Xizang (Tibet) Plateau, in the upper reaches of the Changjiang River and on the highest terrace of China's general topography. Forests in this region play an important role in water and soil conservation (Yang *et al.* 1992; Li *et al.* 1990). Since 1950, the scientific research has been carried out along with the large-scale exploitation of forests in this region. Long-term research conducted includes forest classification, composition, structure, growth, natural regeneration, felling methods, techniques of artificial regeneration, and the ecological changes of logging plots (Yang *et al.* 1956; Wu 1959; Yang *et al.* 1963; Yang *et al.* 1981; Yang 1985; Zhou *et al.* 1984). This paper focuses on distribution characteristics and succession regulation of forests in this region on purpose to make new contributions to the theory of the forestry sciences in alpine region in western China.

Study area

Study area is situated at north of Hengduan Mountains in western Sichuan (28°11′-33°15′N, 100°48′-103°34′E). The parallel mountains and canyons form landform features of this region. According to forest division in Sichuan, the study area is called the dark coniferous forest region with mountains and canyons (Yang *et al.* 1981). Forests of this region distribute in the south of Aba and Ganzi autonomous prefectures at the altitude of 2 500-4 100 m. The annual average temperature is 6-13 °C and annual average precipitation is in range of 700-830 mm. In this region, the main forest soil types are mountain brown soil and mountain dark-brown soil and the main forest types are *Fargesia*/fir/spruce forest; moss/fir/spruces forest; shrub/ fir/spruce forest, etc.

Study methods

After 1950, 700 plots, with an area of 400 m^2 for each, were established by Sichuan Research Institute of Forestry in Miyaluo, Heshui, Maerkang, Songpan, Jinchuan, XiaoJin, Yajiang, and Jiulong, etc. in the alpine and canyon region. In every plot, altitude, slope, exposure, forest crown density, total shrub coverage, total herb coverage, and the names of species, etc. were recorded and the diameter at breast height and height of each individual tree were measured. The seedlings and small trees were counted so as to derive replacement probability matrix.

Results and analysis

Distribution characteristics

The main tree species are *Picea* and *Abies* in the alpine and canyon region, mainly involving *Abies faxoniana*, *A. Sauamata* and *A. georgei*, *Picea balfouriana*, *P. Purpurea*, *P. Likiangensis* and *P. asperata*. The occupation area of those main tree species makes up 80%-90% of the total area of the forest region. *Quercus aquifolioides*, *Betula albo-sinensis*, *B. utilis*, *B. platyphylla*, and *Populus davidiana*, *Tsuga chinensis*, *Larix masteriana* and *Sabina saltu-*

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Biography: XIANG Cheng-hua (1966-), male, Ph Doctor, Professor in Sichuan Research Institute of Forestry, Chengdu 610081, P R China.
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aria, etc., also distribute in the region, besides the main tree species, but their quantities are less.

There are more than 20 species of *Picea* and *Abies* in this region; and they compose of more than 90 forest types. In a certain area, at the same altitude, the forest types and the main tree species are different. The complexity of forest types has close affinity with the complexity of the natural and geographical conditions in this region.

Pure *Abies* forests or mixed *Abies* forests occupy a dominant position. These mainly distribute in Miyaluo, Dajin, Xiaojin and Maerkang. From vertical distribution in this region, *Picea* forest districts distribute between *Abies* forest districts and mixed coniferous and broad-leaved forest districts. The inversion distribution of spruces and firs appears on the margin of this region (Li *et al.* 1990).

Abies forests mainly distribute in the middle and upper reaches of rivers and their branches, narrow valleys and on shaded slopes and at the altitude of over 3 000 m. *Picea* forests mainly distribute in wide valleys and on half-shaded and half-sunny slopes. The secondary thicket or *Quercus* mainly distribute on sunny slopes.

Succession regulation

The natural regeneration is poor under the canopy of primitive spruce and fir forest. There are tens of thousands of regenerated saplings under their forest canopy in the first year, but after the first year, there are only few regenerated saplings left. The factors of high crown density, low temperature, little light, high humidity, thick litter and poor quality and little quantity of tree seed bring about above result. However the natural regeneration in the spruce and fire forest gap is good and forms many young trees of different ages. This indicates that the natural regeneration in the forest gap has continuity and staged features.

Different forest types form diverse succession features. After *Picea* and *Abies* forests are destroyed, they are replaced by *Betula utilis* and *B. albo-siemsis*. After *Abies, Pinus tabulaeformis* or *P. densata* forests are destroyed; they are replaced by *Betula platyphylla* and *Populus davidiana*. If these forests at the altitude of over 3 600 m suffered from serious destruction, they would be replaced by secondary thicket or meadow.

The dark coniferous forests in alpine and canyon region are climax communities with good stability and are difficult to be replaced by other trees in a short time, but human disturbance leads to diverse succession features. These features are shown in Fig. 1, Fig. 2 and Fig. 3.

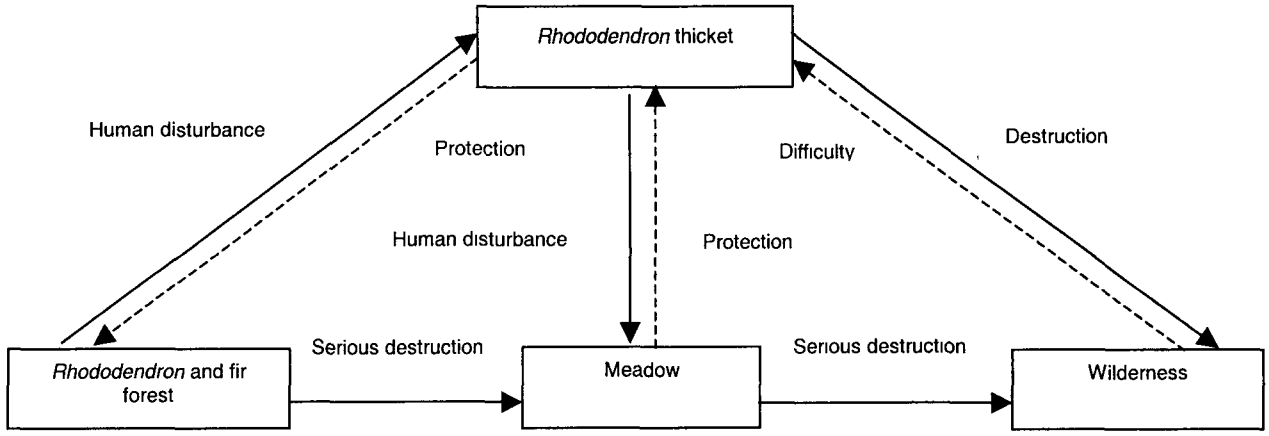

Fig.1 Succession process of *Rhododendron* and fir forest

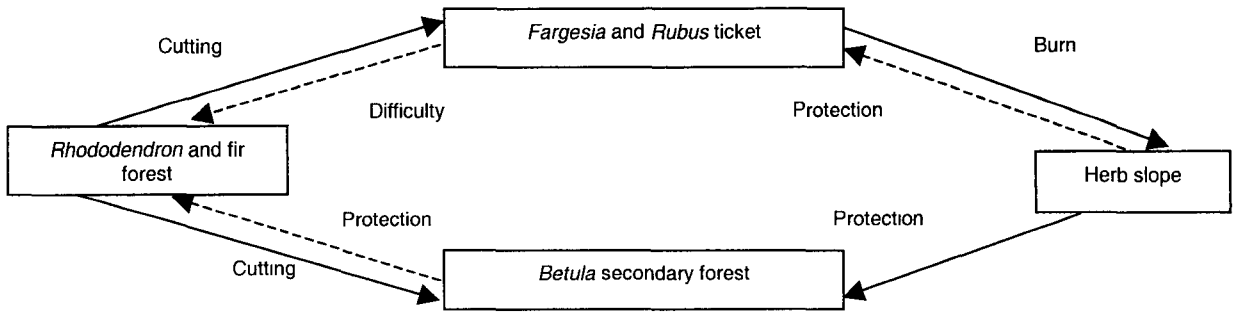

Fig.2 Succession process of *Fargesia*, fir and spruce forest

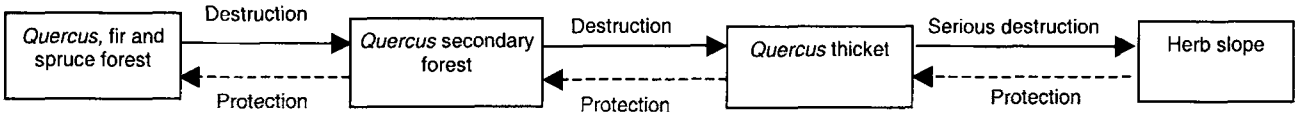

Fig.3 Succession process of *Quercus*, fir and spruce forest

Discussion

Succession law of forest in vertical gradient

There exists close relationship between forest succession and vertical gradient. The succession stages of different forest types and the changes of tree species have a law of vertical gradient (Fig. 4). From *Rohododendron* thicket to *Frgesia* thicket, from *Larix potaninii* forest to mixed *Acer* and *Betula* forest, as well as diverse mixed forests in late succession stage, they all show a pattern of vertical gradient. From the features of succession tree species in vertical gradient, at the elevation of over 3 500 m, the succession tree species are mainly *Larix pataninii* and *Sabina saltuaria* with the characters of cold resistance, while below 3 500 m; the thermophilic *Acer* and *Betula* are dominant species.

Succession procession is related to plant synusia under primary forests. From Fig. 4, it could be known that secondary forest types will formed by plant synusia under the primary forests after the primary forests are destroyed. For example, *Rhododendron* and *Frgesia* thickets are two representative communities respectively in the upper and lower parts of mountain at primary succession stage. However, for moss and fir forest, when the tree stratum is destroyed the moss will disappear due to the change of light. Instead, the intolerant plant *Rubus* under primary forest rapidly grow and form concentrated thickets. After burning or cutting many times, the bush and fir forests are replaced by *Quercus* thicket. *Quercus* thicket is stable, but only in shaded and wet valleys it can develop to high forest. The good environment conditions are advantageous to growth of fir seedlings.

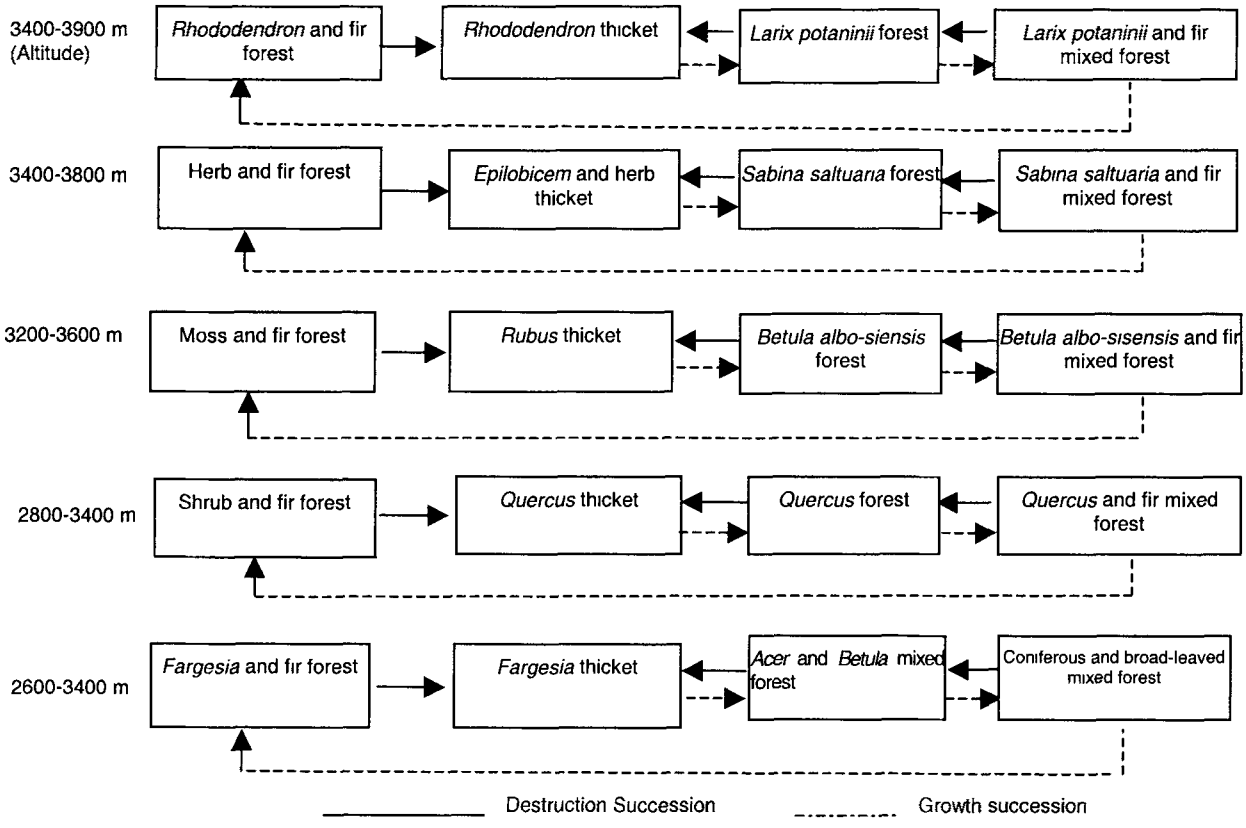

Fig. 4 Succession process of *Abies faxoniana* forest types

Human activities may promote or postpone the succession process. According to investigation, *Rubus* rapidly grow in logging plots during first and second year after cutting, form concentrated thicket in 3-6 years, decline after 7-9 years, and will be replaced by *Populus davidiana*, *Acer* and *Betula* after 10-20 years. This is a succession process under natural condition. If *Rubus* thickets are cut from their roots, they rapidly grow. This measures is not

advantageous to forest regeneration. For purpose of promoting regeneration we may cut *Rubus* in central section of the plant before or after a rain season. This measure could make *Rubus* gradually decline in quantity (Yang *et al.* 1972).

Habitat gradient

The forest succession is evidently impacted by the changes of habitat gradient. The results of regeneration are different on different slope aspects. For example, in dry and cold areas and under *Abies squamata* forest, the regenerated seedlings on shaded slope are 2.5 times as many as that on sunny slope. The natural regeneration under the *Picea purpurea* forest is good on half-sunny slope (2500-3800 seedlings per hectare) but is bad on shaded slope (600 -800 seedlings per hectare). The gentle slope is advantageous to natural regeneration. For examples, the regenerating seedlings under fir forest were 34 900 individuals per hectare on shaded slopes of 5-10°, but only 14 100 individuals per hectare on shaded slopes of 31-45°. The results of natural regeneration are also different at different elevations. For example, under fir forest, there were 15 557 seedlings per hectare at elevation of 3 600-3 700 m. but only 5 900 seedlings per hectare at elevation of 3 900-4 000 m.

Mosaic structure

There exist mutual replacement relationships between spruces and firs in the alpine and canyon region of western Sichuan, particularly in dark coniferous forests, and a stable, mixed fir and spruce forest in large scale is always formed. In this mixed forest, as the dark and damp conditions are favorable to the growth of fir seedlings, the fir seedlings are dominated under the canopy. However the young trees of fir can grow into the main storey only when the old trees die off and forest gap is presented. In the meantime, the occurrence of forest gap also provides good environment conditions for growth of seedlings and young trees of spruce and makes it possible that the young trees of spruce grow into main forest storey. Thus, in the mixed spruce and fir forest, fir and spruce remain fluctuation changes and form fir clump or spruce clump. From horizontal distribution, fir and spruce clumps present a mosaic structure (Yang *et al.* 1992, 1990). For example, in mixed *Abies faxoniana* and *Picea purpurea* forest, *Abies faxomiona* clumps and *Picea purparea* clumps form mosaic pattern. In pure fir forests, the fir clumps in different age classes present a mosaic structure, and the regeneration and the succession of the community occur in cycles.

Expanding regeneration around forest edge

The expanding regeneration can occur in all kinds of sites around forest edge (Yang *et al.* 1956). The distance of expanding regeneration is usually controlled by topography, vegetation and wind direction. According to the investigation on a burn site (30 years ago) at elevation of 4 120 m in Beiyu forestry bureaus, the natural regeneration of *picea balfouriana* was found within 150 m distance from the forest edge. There were 18 000 seedlings per hectare within 50 m from the forest edge, 1 000-2 500 seedlings per hectare within 50-150 m, but no seedling was found beyond the distance 150 m. *Picea likiangensis* seeds could spread to a distance of 115 m from the forest edge, with a good natural regeneration within the distance of 35-65 m from the forest edge.

References

Li Chengbiao, Yang YuPo, Wang Jinxi, *et al.* 1990. Ecological study of Sichuan forest [M]. Sichuan: Sichuan Science and Technology Publishing House, p3-44.

Wu zhonglun. 1959. The distribution of major tree species in alpine forest area of western Sichuan and some proposals for regeneration report and planning of tree species for plantation [J]. Scientia Silvae Sinicae, **5**(6): 465-478.

Yang Yupo, Yang Kaitai, Wang Fangyu, *et al.* 1972. A preliminary research on ecological features of *Rubus amabilis* in cutting-blanks in alpine forest regions of western Sichuan [J]. Collected Papers of Alpine Forestry Researches in Sichuan, **1**: 137-147.

Yang Yupo, Li Chengbiao, Guan Zhongtian, *et al.* 1992. Forest in Sichuan [M]. Beijing: China Forestry Publishing House, p193-362.

Yang Yupo, Zhou Dezhang, Qiu Jinxian, *et al.* 1985. A handbook of alpine silviculture [M]. Sichuan: Sichuan science and Technology publishing House, p150-186.

Yang Yupo, Li Chengbiao, Zhou Dezhang, *et al.* 1963. On the artificial regeneration of cutting blanks in alpine forest area of western Sichuan [C]. In: Selections from 1962 annual meeting papers of China Forestry Society. Beijing: Agriculture publishing House, 99-111.

Yang Yupo, Ye Zhaoqing, Li Chengbiao, *et al.* 1956. Preliminary observations on the natural regeneration under fir and spruce forest canopies in alpine areas of southwestern China [J]. Scientia Silvae Sinicae, **2**(4): 337-354.

Yang Yupo, Li Chengbiao, Yang Qinzhou, *et al.* 1981. A preliminary study of forest division in Sichuan [J]. Journal of Southwest Teacher's College, **6**(1): 107-118.

Zhou Dezhang, Yang Yupo, Huang Lilong, *et al.* 1984. Changes of ecological factors on the cutting-blanks of subalpine fir and spruce forests in western Sichuan [J]. Scientia silvae sinicae, **20**(2): 132-138.